# Bidirectional buck/boost converter with GAN technology


Graduate

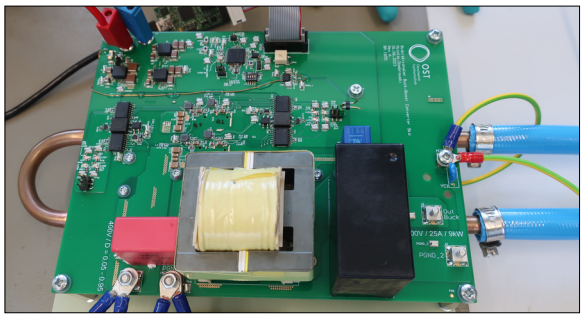
**Nicolai Dombrowski**


Introduction: The demand for powerful technologies is constantly increasing. Wide-band gap semiconductor technologies are more in favor than ever in power electronics, as they are capable of withstanding high voltages with low losses. In addition to silicon carbide (SiC), which is already well researched, the semiconductor gallium nitride (GaN) is increasingly gaining ground in the market. Compared to SiC, this semiconductor is still a young technology, which is not yet fully mature. For the company Regatron, this semiconductor technology is now to be researched in more detail and its performance investigated. Of particular interest are the resulting switching losses and conduction losses. As the switching frequency increases, the size of the inductor or transformer in converters decreases. If you are to maintain a competitive position in the market, you must design your devices to be more compact and efficient. The latest TopCon series (G5) from Regatron uses SiC semiconductors. The aim of this work is to gain knowledge about GaN technology in comparison to SiC technology.

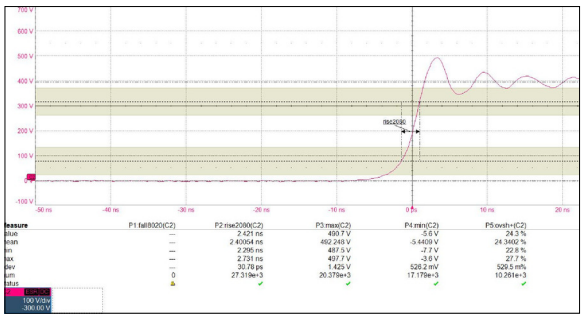
Approach: For this investigation, a design for a bidirectional buck/boost converter is developed. A similar topology is already used in the G5, but was realized with SiC technology. The scope of the work included on the one hand the calculation of the converter, a simulation to estimate temperatures and losses, a development of a cooling concept, design of schematic and layout and following measurements to verify simulation and calculations. A GaN HEMT was chosen for the design, which uses a direct-drive configuration and has an integrated gate driver and feedback signal of junction temperature. Using this feedback signal, an approach was devised to determine the switching and conduction losses. This eliminates the need for current measurement in the HEMTs, which means that no additional parasitic elements are added in the design. It was clear since the beginning that the layout was the key factor in minimizing losses and optimizing performance of the semiconductors.

Result: A bidirectional buck/boost converter could be successfully developed, which can be operated with a power of 9 kW and has an efficiency of > 99 %. Through an optimal layout design, the inductance of the critical loop could be brought below 2 nH. As a result, the overshoot at the switch node was only 24 %. The estimated losses from the simulation model did not vary much from the measured ones, making the model a good approximation. The condition that the PCB should not heat up more than 50 °C could only be met to a limited extent. It was shown that good performance can be achieved with GaN technology and that the semiconductor is a possible alternative to SiC for the Regatron company.

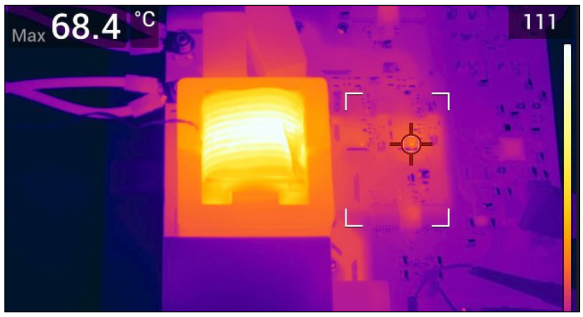
**Bidirectional Buck/Boost Converter**
Own presentment



**Measurement at the switch node at (400 V, 22.5 A , D = 0.5)**
Own presentment



**Temperature change after 20 min endurance test (400 V, 22.5 A , D = 0.5)**
Own presentment




Advisor
**Simon Nigsch**

Co-Examiner
**Prof. Dr. Daniel Gstöhl**

Subject Area
**Electronics and Control Engineering**

Project Partner
**Regatron AG, Rorschach, St.Gallen**